Special section of the T-MOSAiC Newsletter on Remote Sensing

In this newsletter, we continue a special section with graphical abstracts and small articles focused on a specific theme, edited by the Action Group Chairs. In this edition, **Remote Sensing** is the theme, and our next theme will be **Arctic Microbiomes**. We look forward to your contributions to this and other themes in future newsletters.

SPECIAL ISSUES

Special T-MOSAiC Issue of Arctic Science

The T-MOSAiC special issue of *"Arctic Science"* is open for submissions until March 31st 2022. Please visit the T-MOSAiC website for updated information or contact the secretariat: https://www.t-mosaic.com/

Special T-MOSAiC Issue on Arctic Terrestrial Pollution

The Environmental Pollution Journal (IF: 6.792) is open for submissions. This special issue publication aims to provide original research on Arctic Terrestrial Pollution (including Coastal Areas). This special issue will be edit by João Canário (University of Lisbon, Portugal), Katrin Vorkamp (Aarhus University, Denmark), Mark Mallory (University of Acadia, Canada) and Scott Zolkos (Woods Hole Research Center, USA). Deadline for submissions September 30, 2021.

Special T-MOSAiC Issue on Polar and Alpine Microbiology

The Arctic Microbiomes AG is editing a special issue in journal "Frontiers in Microbiology". On the topic Digitizing Frozen Earth - Revealing Microbial Diversity and Physiology in the Cryobiosphere through ´Omics´ Tools, Volume II", this SI is now open online and ready for submissions until August 14th, 2021. The editors of this SI include Anne Jungblut, Jérôme Comte and Birgit Sattler.

frontiers in Microbiology

Special Issues on Remote Sensing

Special joint Issue of Journal of Unmanned Vehicle Systems (changing to Drone Systems and Applications) / Arctic Science: 'Unoccupied Vehicle Systems in Arctic Research and Monitoring' All papers published in this collection will be made open access at no cost to authors with a flexible deadline of an expression of interest this summer and a deadline in the autumn. Guest Editors: Dr. Isla Myers-Smith, Dr. Jeffrey Kerby, Dr. Dustin Whalen.

Special issue of Remote Sensing: 'Advanced Technologies in Wetland and Vegetation Ecological Monitoring' with a deadline of 31 March 2022. Guest Editors: Dr. Sergio Vargas Zesati, and Dr. Jeremy May.

Special issue of JGR Biogeosciences: 'The Earth in living color: spectroscopic and thermal imaging of the Earth: NASA's Decadal Survey Surface Biology and Geology Designated Observable' with a deadline of 31 August 2022. Guest Editors: David S Schimel, Benjamin Poulter, Natasha Stavros, Phil Townsend, Nancy Glenn.

Special issue of Remote Sensing: 'Multi-Scale Analysis for Detecting the Processes, Causes, and Impacts of Permafrost Change and of Disruptive Events' with a deadline of 30 Nov 2021. Guest Editors: Michael Lim, Gonçalo Vieira and Dustin Whalen

CONFERENCES

Scientific Session at ASM2021 on Artic Microbiomes endorsed by the T-MOSAiC correspondent AG

The ArcticChange2021 conference will take place online in December 2021. The call for submission of abstracts is now open, and the Arctic Microbiomes AG is pleased to endorse a scientific session entitled, "Microbiomes as sentinels of a changing Arctic" (TER48), in the "Terrestrial" section of the meeting's topical sessions. The abstract for this session is:

"Among the life forms that live in Arctic environments, microorganisms are the major contributors to nutrient and energy cycles, biodiversity and biomass. Microbial processes underpin Arctic food webs. Therefore, understanding their dynamics and interactions is vital to understanding the ecology of the biome as a whole, especially considering the rapid warming in this region. Although the impact of climate change on microbial communities remains unclear, the unique microbial ecosystems associated with fragile Arctic environments such as glaciers, ice-covered seas and permafrost will surely be adversely affected. Changes in microbial communities can ripple throughout food webs and alter the availability and quality of resources collected by Northerners on the land, directly impacting their microbiomes. Therefore, the response of microbial communities to warming will impact not only ecosystem health but also human health. This session aims to advance our understanding of environmental and human microbiomes and how they interact and overlap in the context of a rapidly changing Arctic."

For more information, please use this *link*.

CALLS

The call for abstracts for the Arctic Change 2020 Meeting is now open until September 17. Arctic Change is organized by our partner ArcticNet and aims to bringing together researchers and partners from around the world to discuss Arctic issues. This year's meeting will be virtual, from December 6 to 10, and several T-MOSAiC related scientific sessions are scheduled. More information is available at: https://arcticnet.swoogo.com/2021?lang=en

Special Section: Remote Sensing

Edited by Gonçalo Vieira and Annett Bartsch, co-chairs of the Remote Sensing Action Group

Remote sensing data and analysis are unique in providing a better understanding of the vast, remote and diverse areas of the Arctic. The implementation of open data policies by several space agencies, the increasing number of high-resolution and multispectral satellites, the decreasing costs of remotely sensed data, the development of cloud-based platforms, as well as the recent developments in Unmanned Aerial Systems, are allowing for amazing developments in remote sensing applications in the Arctic and beyond. As defined in its creation, the T-MOSAiC remote sensing action group aims at shortening the path between field scientists and the remote sensing community, by increasing the availability of calibration and validation data at the circumpolar scale. The action group makes use of UAV and satellite data collected with different sensors to improve the data and models that address issues such as: permafrost characteristics, thaw lake dynamics, coastal erosion, vegetation community dynamics and infrastructure. The activities of the action group have been framed by several international workshops organized withing T-MOSAiC. These allowed to find synergies and promote cooperation with and between existing projects, as well as to delineate new joint applications for funding that lead to some of the projects presented in this special section. The action group is also involved in international networks, such as the High-Latitude Drone Ecology Network (HILDEN - https://arcticdrones.org) and the Permafrost Coastal Systems Network (PerCS-NET - https://permafrostcoasts.org) that promote joint research on remote sensing of the Arctic terrestrial environments.

I would like to thank all the colleagues that contributed to this special issue and look forward to more contributions on new or existing projects in the forthcoming T-MOSAiC newsletters. I take this opportunity to wish to all of you that can do it, a very fruitful field season. To all the others, have a great summer and let's hope we can soon get back to the field for new data gathering. Stay safe.

Drone data reveal complexity not captured by satellite greening trends

Jeffrey Kerby, Aarhus University and Isla Myers-Smith, University of Edinburgh, United Kingdom

The High Latitude Drone Ecology Network (HiLDEN) is working as a part of the T-MOSAiC project to compare high-resolution imagery of land-cover and aboveground productivity to trends in satellite observations across Arctic tundra ecosystems. We are over 40 data contributors working in 73 landscape sites spanning all Arctic nations.

Data collection started in 2017 - 2019 and has resumed again in the summer of 2021. This new phase of data collection in Greenland, Russia, Fennoscandia and regions of North America will facilitate comparisons of fine-scale change over time. Through this research, we are capturing the diversity of tundra landscapes to interpret long-term changes in vegetation and land-surface dynamics observed by satellites.

Our research is identifying the patterns and mechanisms behind Arctic greening trends that can only be detected using higher resolution data. With this work we hope to better understand the complexity in Arctic greening trends and inform estimates of vegetation responses to warming across the circumpolar Arctic.

For more information on protocols, methods and network collaborations, please visit ArcticDrones.org.

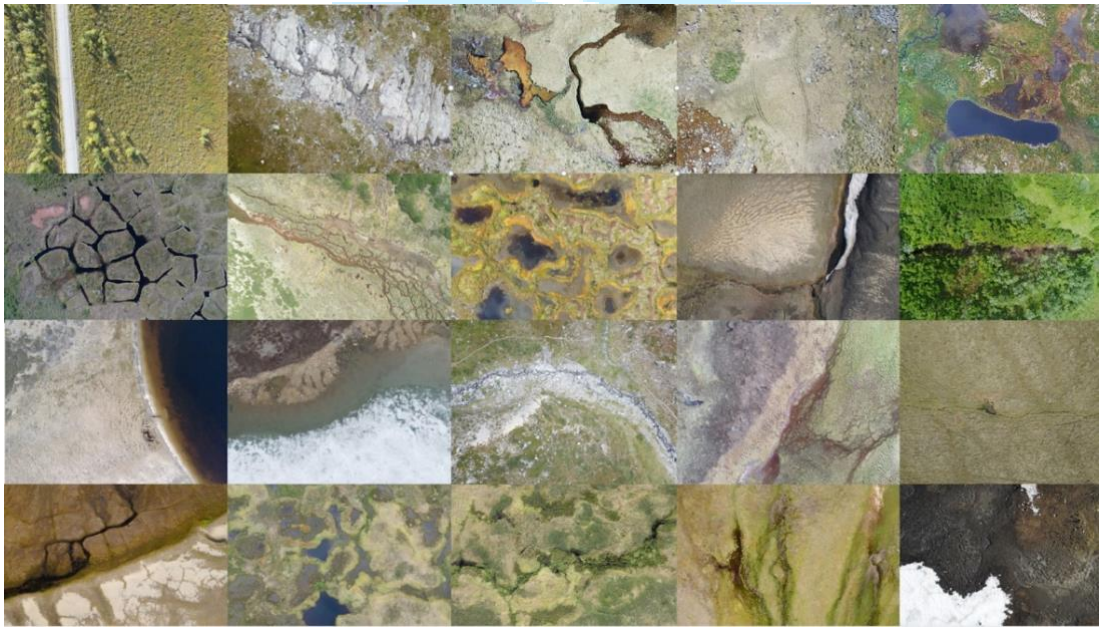

Figure 1 - Drone imagery of tundra sites around the Arctic from the High Latitude Drone Ecology Network.

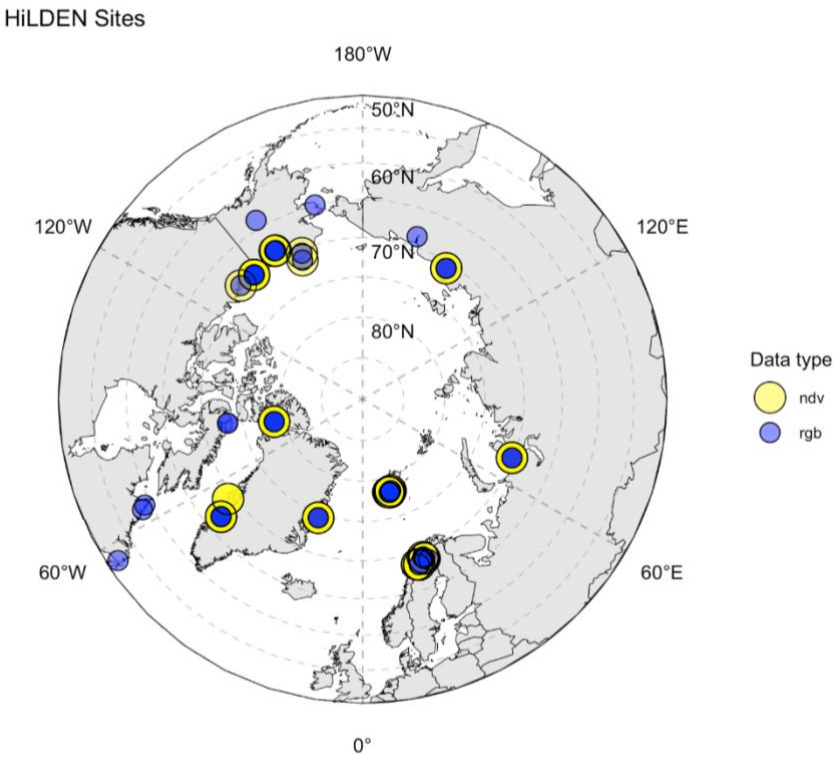

Figure 2 - Map of the locations of data contributions through 2020 for the High Latitude Drone Ecology Network.

Earth Observation for Permafrost – dominated Arctic Coasts - EO4PAC

Annett Bartsch, b.geos, Austria

EO4PAC (Earth Observation for Permafrost – dominated Arctic Coasts) is a new project linking the T-MOSAIC action groups on remote sensing, permafrost, transects, coasts and infrastructure. The project is funded through the ESA Polar Science Cluster - Collaborative Research and Networking Actions Program and had its kick-off in July 2021, running for two years. It aims at the development of a roadmap for the next generation of the Arctic Coastal Dynamics database. The focus is on complementation of in situ records with satellite data across the entire Arctic. The project sub-tasks are lead by Hugues Lantuit, Gonçalo Vieira, Julia Boike and Guide Grosse and the overall action is coordinated by Annett Bartsch
The kick-off of the European Space Agency project EO4PAC took place in mid-July. One of the datasets which will be utilized and evaluated in cooperation with the T-MOSAIC Permafrost AG is the just released new version of the CCI+ Permafrost project. It includes active layer thickness, ground temperature and permafrost extent covering the years 1997 to 2019. The dataset is available under https://climate.esa.int/de/projects/permafrost/data/ and can be visualized on the AWI map portal (see figure).

The EO4PAC plans for CCI+ data use will be presented at the upcoming user workshop on 27th September 2021: https://climate.esa.int/de/projects/permafrost/workshops/

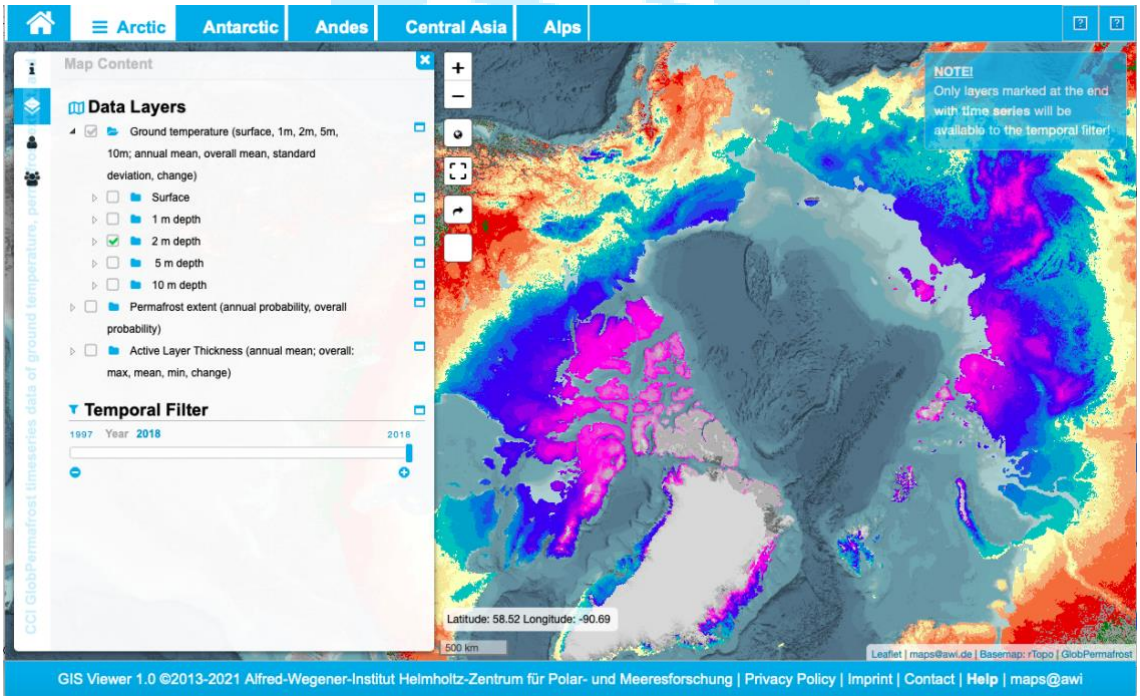

Figure 1: Time series visualization of CCI+ Permafrost data at the AWI map portal (https://bit.ly/3xeMFaP). It is part of the map collection established as part of ESA GlobPermafrost: https://globpermafrost.info/products-and-data-access

LANDMOD - Land use as a modulator of land cover transitions and the ecosystem–atmosphere carbon balance

Timo Kumpula, University of Eastern Finland, Finland

Drone data has been collected with RGB, multispectral, hyperspectral and thermal infrared sensors. The EC tower was launched with chamber measurement campaign.

LANDMOD lead by professor Timo Kumpula from University of Eastern Finland. LANDMOD is a multi-disciplinary project unravelling the impacts of land use on land cover changes and their consequences for the climate. We particularly look at reindeer management strategies as the type of land-use and focus on depicting land cover differences on wetlands. The main objectives are 1) to contribute understanding of the rates, magnitudes and mechanisms of land cover changes under different reindeer management strategies and 2) to quantify how the differences in land cover reflect on the release and uptake of CO2 in a landscape level. Besides estimating the impact of land use today, we will also estimate the influence of past land use on the cumulative carbon balance. With these approaches, the project will contribute understanding on how and why the rates and magnitudes of land cover transitions vary at high latitudes in northern Fennoscandia, and how these feedback to the atmosphere.

Epstein, H. E., D. A. Walker, G. V. Frost, M. K. Raynolds, U. Bhatt, B. C. Forbes, J. Geml, E. Kaarlejävi, et al. 2021. Spatial patterns of arctic tundra vegetation biomass, NDVI, and LAI on different soils along the Eurasia Arctic Transect, and insights for a changing Arctic. *Environmental Research Letters* 16:014008. doi: 10.1088/1748-9326/abc9e3.

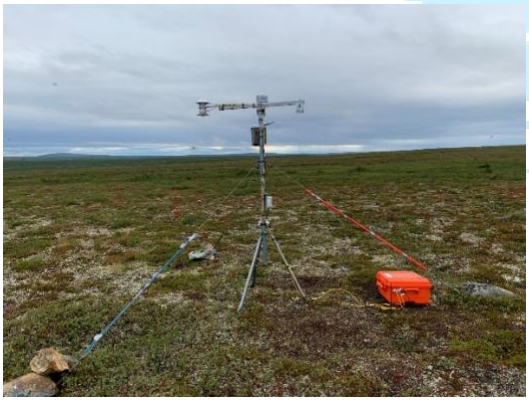

Figure 1: Updated albedo-met station with new sensors. Stations were set up first time in 2013.

Figure 2: Dr. Miguel Villoslada working with the Specim IQ hyperspectral field camera.

Synergistic use of remote sensing and field observations for assessing recent changes in the Beaufort Sea coast (Canada)

Gonçalo Vieira, CEG/IGOT – University of Lisbon, Portugal

Arctic permafrost coasts are major carbon (Schuur et al., 2015) and mercury pools (Schuster et al., 2018). They represent about 34% of the Earth's coastline, with long sections affected by high erosion rates (Fritz et al, 2017), increasingly threatening coastal communities. Year-round reduction in Arctic sea ice is forecasted and by the end of the 21st century, models indicate a decrease in sea ice area from 43 to 94% in September and from 8 to 34% in February (IPCC, 2014). An increase of the sea-ice free season leads to a longer exposure of coasts to wave action. Further, climate warming is also expected to modify the contribution of terrestrial erosion (Ramage et al., 2018, Irrgang et al., 2018).

The project NUNATARYUK contributes to several T-MOSAiC action groups, with the remote sensing activities in the Canadian Beaufort Sea coast being integrated in strategy of the remote sensing action group. The team includes several organizations from Europe and Canada associated with the work package 2.1 of Nunataryuk: the University of Lisbon, the Alfred Wegener Institut, Natural Resources Canada and b.geos. The team is focusing on assessing coastal change rates in the coasts of the Arctic Ocean and their controlling factors, with the Canadian Beaufort coast as a case-study.

The surveying methodology is based on the synergistic use of satellite imagery and field data, with the main approaches being the following: i. a high-resolution update of the coastline mapping and change rates using new Pleiades (CNES) satellite acquisitions from 2018, 2020 and 2021, ii. surveys using RTK-UAS aerial imagery of long-term monitoring sites, iii. application of TerraSAR-X (DLR) staring spotlight scenes and PAZ (HisdeSat) at key sites to monitor intraseasonal dynamics of coastal changes. Support on Pleaides imagery access is provided by the WMO Polar Space Task Group, to TSX by DLR and to PAZ by HisdeSat.

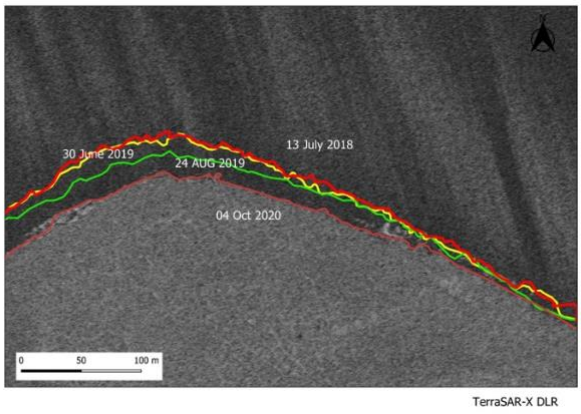

Figure 1: Fast eroding coast at Kay Point delineated from the analysis of TerraSAR-X imagery (DLR) (Mora et al., in prep.).

The following topics have been analyzed within T-MOSAiC and the results are being prepared for publication:

- Coastal dynamics in the Yukon coast and McKenzie delta from 1985 to 2018;
- Coastal characterization and dynamics of Tuktoyaktuk Peninsula;
- Coastal characterization and dynamics from Cape Parry to Paulatuk (Darnley Bay);
- Geomorphological analysis and dynamics of the Pingo Canadian Landmark Park;

- Flood modelling of the hamlet of Tuktoyaktuk driven by LiDAR and UAS data;
- Assessment of intraseasonal coastal changes using TSX and PAZ data.

References:

Fritz, M., Vonk, J. E., & Lantuit, H. (2017). Collapsing Arctic coastlines. *Nature Climate Change*, 7(1), 6–7. https://doi.org/10.1038/nclimate3188

Intergovernmental Panel on Climate Change. (2014). Climate Change 2014 Synthesis Report - IPCC. Climate Change 2014: Synthesis Report. Contribution of Working Groups I, II and III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change, 2–26. https://doi.org/10.1017/CBO9781107415324

Irrgang, A. M., Lantuit, H., Manson, G. K., Günther, F., Grosse, G., & Overduin, P. P. (2018). Variability in Rates of Coastal Change Along the Yukon Coast, 1951 to 2015. *Journal of Geophysical Research: Earth Surface*, 123(4), 779–800. https://doi.org/10.1002/2017JF004326

Ramage, J. L., Irrgang, A. M., Morgenstern, A., & Lantuit, H. (2018). Increasing coastal slump activity impacts the release of sediment and organic carbon into the Arctic Ocean. *Biogeosciences*, 15(5), 1483–1495. https://doi.org/10.5194/bg-15-1483-2018

Schuster, P. F., Schaefer, K. M., Aiken, G. R., Antweiler, R. C., Dewild, J. F., Gryziec, J. D., Gusmeroli, A., Hugelius, G., Jafarov, E., Krabbenhoft, D. P., Liu, L., Herman-Mercer, N., Mu, C., Roth, D. A., Schaefer, T., Striegl, R. G., Wickland, K. P., & Zhang, T. (2018). Permafrost Stores a Globally Significant Amount of Mercury. *Geophysical Research Letters*, 45(3), 1463–1471. https://doi.org/10.1002/2017GL075571

Schuur, E. A. G., McGuire, A. D., Schädel, C., Grosse, G., Harden, J. W., Hayes, D. J., Hugelius, G., Koven, C. D., Kuhry, P., Lawrence, D. M., Natali, S. M., Olefeldt, D., Romanovsky, V. E., Schaefer, K., Turetsky, M. R., Treat, C. C., & Vonk, J. E. (2015). Climate change and the permafrost carbon feedback. *Nature*, 520(7546), 171–179. https://doi.org/10.1038/nature14338

THAWPOND – Remote sensing analysis of vegetation and thaw pond colour dynamics in the discontinuous permafrost zone

Pedro Freitas, CEG/IGOT – University of Lisbon, Portugal

Warming is exposing permafrost to degradation through active layer thickening and abrupt thawing, generating large consequences for ecosystems, terrain stability, hydrology, and the global carbon cycle. The most frequent and widespread mechanism of abrupt permafrost thaw is the formation and development of thermokarst lakes and ponds. These dynamic aquatic environments generally exhibit less than 10,000 m2 and depth bellow 5 meters. Throughout their life span they act as biogeochemical hot spots for the release of carbon dioxide (CO2) and methane (CH4) to the atmosphere, through microbial and photochemical transformations. There is an urgent need for including these new greenhouse gas fluxes in climate projections. However, currently there is no consensus on their spatial and biogeochemical representativity, making their consideration in Global Climate and Earth System Models difficult.

The project THAWPOND – Remote sensing analysis of vegetation and thaw pond colour dynamics in the discontinuous permafrost zone is led by the University of Lisbon and involving the Centre d'Études Nordiques – Université Laval. It aims at providing new advances in the understanding of the spatial and temporal dynamics of thaw lakes and ponds biogeochemistry, as well as studying the vegetation colonizing their vicinity, by using new multi-scale remote sensing data supported by unprecedented resolution ground truthing. For this we have been collecting and analyzing data on the optical and chemical properties of the lakes, which allow for calibrating, training and classifying Sentinel-2 satellite imagery. Satellite and field observations supported by advanced spatial analysis and new remote sensing techniques will provide unprecedented understanding on the dynamics of the optically active (e.g. blue-green algae phycocyanin, chlorophyll-a, fluorescent dissolved organic matter and turbidity) and even non-optically active (e.g. dissolved oxygen) constituents of thaw lakes and ponds in wide regional permafrost transects.

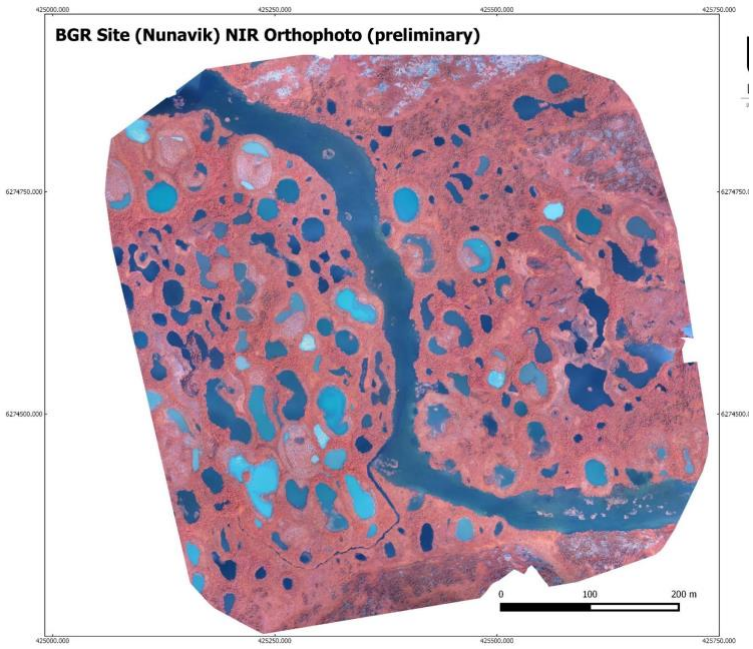

Figure 1: Ultra-high resolution orthomosaic of thermokarst ponds in BGR (near-infrared false colour composite) surveyed with UAS.

Our recent findings suggest that the Sentinel-2 satellite will be able to monitor the spectral properties of waterbodies with a surface area above 350 m2, which is a promising minimum detection threshold for a totally free to use satellite, offering multispectral data at 10, 20 and 60 meters spatial resolution. Nevertheless, this detection threshold can only be used as reference if the waterbody boundaries are first delineated through very-high resolution imagery. Nanosatellites, such as those from PlanetScope lab, allow for very high resolution (3 m) multispectral continuous acquisitions opening new ways on early stage thermokarst detection. We currently have compiled ci. 70 000 km2 of PlanetScope imagery for northern Quebec and the Mackenzie Delta. This data will be used for lake delineation using Deep Learning algorithms. Sentinel-2 data will be used for building a lake colour change database from 2015 to 2022.

We have been facing specific challenges in remote sensing mapping and optical monitoring of small waterbodies, ranging from spatial resolution to co-registration errors. In addition, vegetation surrounding the waterbodies is able to cast shadows throughout the year, causing difficult to assess reflectance biases and challenging the study of water spectral characteristics. Regarding the vegetation cast shadow impact on lake reflectance, our recent results that will feed a manuscript titled “Ultra-high resolution reflectance assessment of cast shadow impacts onto thermokarst lakes in the boreal forest-tundra transition zone” suggest that the impacts are larger on brighter and turbid lakes, where the differences between sunlit and shaded surfaces were estimated to be around 3.7 to 5%, depending on the band. In terms of the conditioning factors, cast shadow impacts are larger in smaller, narrow and elongated lakes closer to trees and surrounded by high and dense shrubs. Temporally, those impacts will amplify as the growing season ends due to dropping solar elevation angles with an estimated mean area of shaded surfaces onto the lakes of 36% in our study site near Kuujjuarapik in Northern Quebec.